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PUBLIC SERVICE COMMISSION OF WISCONSIN

Report to the Legislature on the Development of Distributed Electric Generation in the State of Wisconsin

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Executive Summary

In October 1999, the Legislature passed Wisconsin Act 9, which included a provision (Wis. Stat. § 196.025(4)) requiring the Public Service Commission (PSC or Commission) to "study the establishment of a program for providing incentives for the development of high-efficiency, small-scale electric generating facilities…." The legislative interest in what is generally referred to as Distributed Generation (DG) reflects a growing interest in decentralized electrical generation on the part electric consumers, utilities, and independent power producers. The United States Department of Energy (DOE) forecasts that DG could provide as much as 20 percent of all new US power generation capacity additions by 2010.

The small-scale, high-efficiency distributed generation technologies studied for this report include photovoltaics (solar), wind power, fuel cells, microturbines, internal combustion powered generators, and combined heat and power (CHP). The report and its findings and recommendations are based on a survey of stakeholders, comments from other states, extensive literature research, seminars, and input from the State of Wisconsin's Departments of Administration (DOA), Natural Resources (DNR), and Revenue (DOR).

The renewable energy technologies of wind and photovoltaics are considered high efficiency by definition. The study finds, for fossil fuel technologies, that it is reasonable to define "high efficiency" as a combined heat and power efficiency greater than 50 percent and that "small-scale" refers to a generator that has an average annual capacity of 1 megawatt (MW) or less.

The study compares air emissions for different technologies. It identifies a concern with the cumulative effects of numerous diesel or gas-powered distributed generators that individually would be exempt from the air permit requirements of the federal Clean Air Act (CAA).

Disincentives may exist for the growth of DG in Wisconsin in the form of complex rules and practices imposed on small, non-utility owned DG. Establishment of a stakeholder collaborative group to develop a set of streamlined rules and contract provisions would provide an incentive for properly sited, small-scale DG. The report further recommends that a statewide interconnection standard be created consistent with national standards developed by the Institute of Electrical and Electronics Engineers (IEEE), Underwriters Laboratories (UL), and the National Fire Protection Association (NFPA).

Financial incentives examined in the report include expansion of the net energy-billing tariffs; buy-back rates that are based on the environmental benefits, and a production tax credit for technologies with reduced environmental impacts. A recommendation is also made that state agencies provide assistance to local units of government in siting of small-scale, high-efficiency distributed generation.

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Chapter 1 - Why High-Efficiency, Small-Scale Generation?

Introduction

This report to the legislature provides an assessment of the "high efficiency, small-scale" electric generation technologies, and the environmental impacts and regulatory environment associated with these technologies. It also proposes a program of incentives to encourage this type of generation. This report has been prepared to address legislation passed in 1999 that states:

> Wis. Stat. § 196.025(4):
>
> (a) In consultation with the department of administration and the department of revenue, the commission shall study the establishment of a program for providing incentives for the development of high-efficiency, small-scale electric generating facilities in this state that do either of the following:
>
> 1. Provide benefits in the form of support for electric distribution or transmission systems, power quality or environmental performance.
>
> 2. Employ technologies such as combined heat and power systems, fuel cells, micro-turbines or photovoltaic systems that may be situated in, on or next to buildings or other electric load centers.
>
> (b) No later than January 1, 2001, the commission shall submit a report of its findings and recommendations under par. (a) to the chief clerk of each house of the legislature for distribution to the appropriate standing committees under s. 13.172(3).

For the purpose of this report, small-scale high-efficiency electrical generation, more commonly known as distributed generation (DG) or distributed power (DP), includes the combustion technologies of small internal combustion (I/C) engines, small-sized gas turbines, and micro-turbines; the renewable generation technologies of photovoltaics, wind power, and hydro power; as well as fuel cells. Fuels cells may or may not be renewable depending on the source of their hydrogen fuel. Distributed resource technologies such as flywheels, super conducting magnetic storage devices, and advanced batteries were not included in this report because they are not generating devices. Hydropower generation is not discussed in depth in this report because of limited siting opportunities for new facilities in Wisconsin.

In this report, small-scale is defined as a generating capacity up to 1 megawatt (MW) and high-efficiency is defined as a combined heat and electric efficiency greater than 50 percent. Renewable generation sources are considered high efficiency by definition.

There is growing interest in DG technologies on both sides of the meter, by utilities as well as residential, commercial, and industrial customers. The United States Department of Energy (DOE) forecasts that DG could provide as much as 20 percent of all new U.S. power generation capacity additions through 2010. The Electric Power Research Institute (EPRI) estimates the DG market will be 2.5 gigawatts per year by 2010. Market penetration will depend upon lower installed costs, fuel costs, and the economies of scale that various technologies are able to achieve.

Why is there so much interest in alternatives to centralized power generation? There are many reasons. Customers are interested in the potential for environmentally clean, reasonably priced, reliable, high quality power. For electric power utilities, the benefits are lower line losses, deferred transmission and distribution (T&D) upgrades, grid support, improved system reliability, and reduced need for peaking capacity.

This report describes DG technologies; their efficiencies and emission rates; along with technical, regulatory, and financial barriers that may slow the development of these technologies in Wisconsin. It also recommends a program of incentives to overcome some of the potential barriers.

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Chapter 2 – Current State of Distributed Generation

This chapter describes the technologies most commonly used for DG; fuel cells, microturbines, photovoltaics, small internal combustion engines, wind turbines, and combined heat and power (CHP) (which can be used with the combustion and fuel cell technologies). Microturbines and I/C engines are nonrenewable combustible energy resources; photovoltaics and wind are classified as noncombustible renewable energy resources and the classification of fuel cells depends on sources of fuel used.

State energy priorities are established by Wis. Stat. § 1.12(4):

> PRIORITIES. In meeting energy demands, the policy of the state is that, to the extent cost-effective and technically feasible, options be considered based on the following priorities, in the order listed:
>
> (a) Energy conservation and efficiency.
>
> (b) Noncombustible renewable energy resources.
>
> (c) Combustible renewable energy resources.
>
> (d) Nonrenewable combustible energy resources, in the order listed:
>
> 1. Natural gas.
> 2. Oil or coal with a sulphur content of less than 1 percent
> 3. All other carbon-based fuels.

Photovoltaics

Photovoltaics directly convert sunlight into electricity through the use of photovoltaic cells, which are grouped together to form a panel. Photovoltaic panels can be used in small groups on rooftops or as part of a substantial system for producing large amounts of electrical power. The amount of energy produced by a photovoltaic system depends upon the amount of sunlight available. The intensity of sunlight varies by season of the year, time of day, and the degree of cloudiness. Currently, photovoltaic generated power is less expensive than conventional power where the load is small or the area is too difficult to serve by electric utilities. Recent breakthroughs may reduce the cost of producing electricity with photovoltaic systems to 10 to 12 cents per kWh or lower. This compares to 3 cents per kWh for fossil central station power generation.

While further advances in solar technology are likely, some technologies are available today. As a result of private and government research, photovoltaic systems are becoming more efficient and affordable. Utilities also fund research in these same areas through membership in EPRI. With continued improvements, it is likely that photovoltaic technologies will become increasingly cost competitive with conventional generation sources.

Compared to traditional methods of electric generation, photovoltaic systems have few environmental concerns. The primary environmental impact of large ground arrays is visual and can be solved by designing them to blend with their surroundings.

Wind Turbines

Wind energy is converted to electricity when wind passes by blades designed like those of an airplane propeller mounted on a rotating shaft. As the wind moves the blades, the rotation of the shaft turns a generator that produces electricity.

Three factors affect wind machine power: the length and design of the blades, the density of the air, and wind velocity. Blades are shaped and positioned to take advantage of different wind velocities so that, depending on design, one wind machine may produce power in a different range of wind velocities than another. Power output is directly proportional to the length of the blades.

Cold air is denser; therefore, it has more force, or ability to turn the blades. A wind machine in Wisconsin's cold, dense winter air can produce up to 20 percent more than the same machine exposed to the same wind speed but warmer air.

Since output is proportional to the cube of the wind velocity,[1] the speed of the wind is critical for the cost-effective operation of wind machines. Generally, the higher a wind turbine is mounted, the more wind it will encounter.

Working with the Commission staff and other interested parties, Wisconsin electric utilities have established a comprehensive statewide wind resource assessment program (WRAP). This program was ordered by the Commission to encourage wind power development in those areas of the state with the best wind energy potential. For a three-year period, wind speed and direction will be recorded at 13 sites and at 10, 25, 40, and 60 meters above ground level. The

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[1] $P=1/2DAV^3$ (P=power produced; D=air density; A=swept area of the turbine blades; and V=the velocity of the wind in miles per hour.)

information from WRAP is available to the public through the Wisconsin Energy Bureau by calling (608) 266-1067.

Wind energy can have both positive and negative impacts on the environment. Like photovoltaics, wind power does not create air pollution. The primary environmental concerns associated with wind power are potential effects on bird and bat mortality and aesthetics.

Fuel Cells

A fuel cell is an electrochemical device that generates electricity by combining hydrogen from a hydrogen-rich fuel (methane, methanol, propane, or biomass) with oxygen from the air to produce electricity, heat, and water. All fuel cells consist of anode, cathode and electrolyte; much like a battery, except that the reactant fuel is continuously fed to the cell. Electrochemical oxidation and reduction reactions take place at the electrodes to produce electrical current. Each individual fuel cell produces less than one volt of potential, so cells must be stacked to obtain the desired voltage. Typical fuel cell capacity ranges from 2 kilowatt (kW) to 2 MW and have electrical efficiencies that range from 45 to 65 percent. With heat recovery, the efficiency can be as high as 85 percent.

Four types of fuel cells are receiving the most attention today. They are the phosphoric acid fuel cell (PAFC), molten carbonate fuel cell (MCFC), solid oxide fuel cell (SOFC), and proton exchange membrane fuel cell (PEMFC). Figure 2-01 compares operating temperature, efficiency, fuels, size range, and projected costs for the four types of fuel cells.

PEMFCs have just entered the market. Plug Power and General Electric (GE) are marketing a 7 kW PEMFC for residential and commercial use. Ballard Power Systems of Vancouver, British Columbia, is working with the automobile industry on development of transportation applications for the PEMFC. Low operating temperature, 200°F (80°C), means that this type of fuel cell would not be appropriate for CHP, but the low operating temperature allows the PEMFC to be brought up to operating temperature rapidly. Technical issues facing PEMFC include electro catalyst poisoning by carbon monoxide (CO), water management, balance of plant costs, and cell life.

PAFCs have been commercially available since 1993. Today they are marketed by ONSI Corporation, a subsidiary of International Fuel Cell Corporation, which has sold some 250 units worldwide. PAFCs have an operating temperature of 400°F (200°C) and have been demonstrated at sizes ranging from 50 kW to 200 kW. They are 40-50 percent efficient.

MCFCs are high temperature fuel cells that operate at 1,200°F (650°C) and are 65 percent efficient. These offer the potential for internal methane reforming and CHP applications for commercial, light industrial, and distributed power applications. Sizes range from 250 kW to 2.5 MW. Issues that need to be addressed before wide spread commercialization occurs are higher power density, cell life, cost reduction (from $1,000/kW to $200-400/ kW), thermal management, and reliability. Commercial availability for MCFC is projected for 2001-2002.

Figure 2-01 Comparison of Distributed Generation Technologies

	Product Rollout	Size of Market in 2000[1] (Units)	Unit Capacity (kW)	Electrical Efficiency (HHV)	Package Cost ($/kW)[2]	Turnkey Cost – No Heat Recovery ($/kW)	Heat Recovery Added Cost ($/kW)[3]	O&M Cost ($/kWh)	Operating Temp (°F)
Diesel Engine	Commercial	4,000	20-10,000+	36-43%	125-300	350-500	75-150	.005-.010	
Natural Gas Engine	Commercial	1,000	50-5,000+	28-42%	250-600	600-1,000	75-150	.007-.015	
Combustion Turbine-Simple Cycle	Commercial	200	1,000+	21-40%	300-600	650-900	100-200	.003-.008	2400
Microturbine	1999-2000	50	30-200	25-30%	350-750	600-1,100	75-350	.005-.010-	1800
Fuel Cell									
PEMFC	1999	400	50-1,500	50%	2,163	2,563	Included	.005-.010	200
PAFC	1993	250	50-200	45%	2,363	2,763	Included	.005-.010	400
MCFC	2002	<5	250-2,500	65%	2,163	2,563	Included	.005-.010	1200
SOFC	2003	<5	50-2,000	46%	1,963	2,363	Included	.005-.010	1800
Wind	Commercial	6,500	10-1,000	N/A	1,000	1,000		.01	
Photovoltaics	Commercial		1+	N/A	5,000-10,000	5,000-10,000	N/A	.001-.004	

Original table from Power Engineering, April 2000, p. 22.

1. Figures for engines and turbines are from the Gas Research Institute.

   Photovoltaics size of market is not included as market penetration is the weakest of all technologies based on MW sales.
2. Cost per kW figures are from DOE Annual Energy Outlook 2000, Table 37.
   All technologies claim a price reduction of 50 percent (particularly fuel cells) with increased market penetration.
3. Cost of heat recovery for fuel cells is estimated at $400/kW.

SOFCs are projected to be commercially available as early as 2003. They operate in the range of 1,800°F (1,000°C), depending on whether the geometry is tubular or planar. SOFC have potential for use in all the traditional power generating markets including CHP. Relative to the other fuel cell types, SOFC is particularly dependent on development of suitable low-cost materials and fabrication techniques. Electrical efficiency for SOFCs is 46 percent.

Hydrogen, the required fuel source for fuel cells, can be produced from water using electrolysis, with the necessary electricity generated using renewable energy. The National Aeronautic and Space Administration (NASA) is currently working on a "regenerative fuel cell" that would be a closed-loop form of power generation. In the regenerative fuel cell, water is separated into hydrogen and oxygen by a solar-powered electrolyser and fed into the fuel cell to produce electricity and water. The water is then re-circulated to the electrolyser to complete the cycle. However, because this method is relatively expensive, most fuel cell systems use some form of hydrocarbon fuel as their hydrogen source. The use of a hydrocarbon fuel produces gaseous, liquid, or solid waste by-products.

Some source compounds will have fewer and smaller amounts of by-products. The following is a list of hydrogen sources that rank from lowest to highest in by-products:

1. Water
2. Methane
3. Propane and natural gas
4. Gasoline
5. Fuel oil
6. Gasified coal

Fuel cells, because of higher efficiencies and lower fuel oxidation temperatures, emit less carbon dioxide (CO_2) and nitrogen oxides (NOx) per kilowatt hour (kWh) of power generated than turbines or engines that use a combustion process. The overall air emissions are lower for fuel cells, but the difference is not significant for sulfur dioxide (SO_2) or particulates. In Chapter 3, Figure 3-02 compares the emissions from three distributed technologies that use natural gas as the fuel or the source of the fuel.

If fuel re-forming is done on site, heat produced from the fuel cell process powers the reformer. If the re-forming is done off site, the resultant pollutants would be produced off site, and there would be additional pollutants from transporting the hydrogen to the fuel cell site. Unlike gas-fired combustion turbines and combined-cycle units, noise and vibrations associated with fuel cells are practically non-existent because the fuel cell itself has no moving parts.

Microturbines

Microturbines are small gas turbines, self-contained sources of electricity (generally less than 300 kW) and heat that provide a controlled source of on-site power. They can operate in parallel with other units or operate alone. Efficiencies vary from 24 percent to 60 percent depending on initial cost and the utilization of waste heat. Natural gas is the primary fuel utilized although some renewable applications for biogas are being pursued.

Microturbines date back to the 1950-1970 time period, when the automotive market started looking at gas turbine products. Stationary market interest was spurred by the Public Utility Regulatory Policy Act (PURPA) in the mid-1980s and accelerated during the 1990s.

Microturbines are a developing technology that hold the promise of higher efficiencies and potentially lower operating cost. Items that will affect the market for microturbines attractive to widespread development include:

?? The initial price as microturbines move down the price volume curve from their high initial cost

?? Reliability and cost of fuel supply

?? The degree of customer attraction to a "high tech" product

?? The extent to which units demonstrate long-term operating reliability

Existing Market Activities

?? Wisconsin Electric Power Company (WEPCO) is working with the city of Brookfield to install a Capstone 27 kW unit in an EPRI collaborative effort. This demonstration project will be used to meet energy demands at peak use when cost savings are estimated at 10 percent.

?? Wisconsin Public Service Corporation (WPSC) is installing five microturbines at a large dairy farm in DePere utilizing methane gas from an anaerobic digester.

?? Alliant Energy Corporation is a national distributor for Capstone microturbines focusing its efforts in Wisconsin, Iowa, Illinois, and Minnesota.

?? Unicom is distributing Allied Signal microturbines in a 12-state area including Wisconsin.

The primary environmental concerns with microturbines are noise and air emissions. CO_2 and other emissions from natural gas (NG) are relatively low compared to other fossil fuels.

Internal Combustion Engines

At present, the use of I/C engines outnumber all other distributed generation technologies combined. Several factors make I/C engines attractive.

?? Low initial cost

?? Proven technology

?? Readily available infrastructure for purchase/repair

?? The small footprint required for a given amount of energy

An estimated 60,000 MW of installed reciprocating engines and small turbines of 20 MW or less exist in North America.

Mass production results in I\C engines being the lowest direct cost form of DG. (Direct cost excludes the costs of environmental externalities.) For the purpose of this report, direct cost means the cost of purchase and installation.

I/C engines can be fueled by diesel, gasoline, or natural gas. Historically, most I/C engines used for electric power generation, use diesel fuel.

Gasoline engine generator sets are usually not selected for DG applications because of the reasons outlined in the efficiency section. They are available as emergency generators where limited run time of less than 100 hours per year is expected.

Natural gas engines have emerged as a competitive prime mover for the power generation market. Sales have grown from 4 percent to over 20 percent of all engine sales for generation since 1990.

The use of natural gas in I/C engines is expected to increase at the expense of diesel and small turbines. This growth is due to improvements in cost, efficiency, reliability, and emissions.

The additional direct cost for an engine equipped to burn natural gas, rather than diesel fuel, is justified if the unit operates more than 2,000 hours/year.

Existing market activities:

- ?? Diesel engine generator sets are presently the most popular choice for peak and emergency generation.
- ?? Wisconsin Power and Light Company (WP&L) and Madison Gas and Electric Company (MGE) added 120 MW (about 60 units) in various substations in 1999 and 2000 for meeting peak demand.
- ?? Approximately 100 more diesel engine generator sets are scattered throughout the state and used as peaking capacity in various municipalities.
- ?? Generators connected for emergency use at customer sites in Wisconsin are common but the number is not known.

Noise levels and air emissions from diesel engines are major environmental concerns. Air emissions are discussed in detail in Chapter 3.

Combined Heat and Power

Providing both electric power and heat from a single source is called combined heat and power (CHP), also known as cogeneration. While separate heat and power systems are often only 33 percent efficient (67 percent of the fuel energy in wasted), CHP can be 60 to 80 percent efficient by capturing and making productive use of the waste heat on-site. CHP can be used with fuel cells, micro turbines, small gas turbines, and internal combustion engines. Heat recovery lends itself particularly well to small-scale generation because small-scale generators can be located next to heat loads such as green houses, health clubs, food processors, and commercial laundries.

CHP can provide power and steam while burning one third less fossil fuel than would be the case without heat recovery. This means that CHP reduces the adverse effects of burning fossil fuels to power small generators

At the federal level, the DOE has initiated a program to double the use of CHP nationwide by the year 2010. DOE has funded a study conducted by the California Energy Commission that concluded the following:

- Because of the high market barriers, the greatest use of CHP will be with generators over 20 MW.
- CHP systems under 1 MW would be less than one percent of the total due to the high market barriers.
- Streamlined project implementation could lead to greater use of CHP with small generators.
- Financial incentives that increase the market penetration of economically viable CHP has social benefits that accrue to the public.

Distributed Generation Activities in Other States

Several states are addressing DG on a regulatory or legislative level.

Arizona

The Arizona Corporation Commission (ACC) has formed a Distributed Generation & Interconnections (DGI) Workgroup. The DGI Workgroup will draft regulatory language for ACC consideration in the year 2000.

The DGI Workgroup is addressing:

- siting, certification, and permitting;
- market access, metering, and dispatch; and
- interconnection standards.

California

AB1890 requires customers that use on-site generation to pay Competitive Transition Charges (CTC) during the transition period, which ends in 2000. Existing cogeneration facilities are exempt from the CTC, and can expand up to 20 percent of their capacity without incurring CTCs. New cogeneration facilities will be required to pay the CTC until the end of 2000. Fuel cells are likely to be exempt from CTCs. Micro-cogeneration (less than 1 MW) is not exempt from the CTC. However, it can apply for financing of the CTC. The California Public Utility Commission has started rulemaking proceedings to address the following DG issues:

- Interconnection standards
- Ownership and control
- Rate design
- Standard costs

- ?? Distribution wheeling
- ?? Sales of excess capacity
- ?? Net metering
- ?? Stranded costs
- ?? Permit streamlining

Illinois

The Illinois Commerce Commission concluded a study on DG in January 2000. The Commission's report concluded:

- ?? DG located in Illinois could be beneficial to consumers and utilities.
- ?? It was not appropriate to use subsidies or other artificial advantages to foster distributed resources development.
- ?? Artificial barriers to DG development and utilization should be removed.

Massachusetts

The Electric Utility Industry Restructuring Act exempts the following from exit charges:

- ?? facilities with renewable energy and fuel cells;
- ?? cogeneration and on-site generation of less than 60 kW; and
- ?? facilities with on-site generation that will not reduce the utility's revenues by 10 percent.

New Hampshire

Rulemaking proceedings are underway for interconnection requirements for customer-owned solar, hydro, or wind generation resources less than 25 kW.

New Jersey

The Electric Discount and Energy Competition Act exempts on-site generation from transition and societal benefits charges until the purchases displaced by these facilities, in the aggregate, reduce the kWh distributed by the electric utility to 92.5 percent of its 1999 levels.

New York

The New York Public Service Commission has established two working groups to investigate technical requirements and process streamlining for interconnecting DG. Technical interconnection requirements for DG systems less than 300 kilovolt amperes (kVA) in radial distribution systems have been developed.

Texas

The Texas Electric Restructuring Act exempts on-site generation (less than 10 MW) from stranded cost recovery. The Texas Public Utility Commission has adopted interim interconnection technical requirements and standard interconnection agreements.

Virginia

The Restructuring Act requires State Corporation Commission to provide non-discriminatory access to Transmission & Distribution system for distributed generation and to consider expediting permitting process for facilities less than 50 MW and interconnection requirements for facilities less than 500 kW.

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Chapter 3 – Emissions and Efficiency

Air Permits

The Wisconsin Department of Natural Resources (DNR) imposes and enforces emission limitations on stationary sources. DNR emission regulations are based on the national ambient air quality standards (NAAQS), established by the US Environmental Protection Agency (EPA) under the authority of the Clean Air Act (CAA).

The size, location, type of source, or other factors determine the steps needed to obtain a construction permit. The DNR rules state:

> At any site, prior to construction, all stationary gas turbines with a heat input equal to or greater than 10.7 gigajoules per hour (2.97 MW) will need an air pollution control construction permit. Consequently, any stationary source less than 2.9 MW may not need an air pollution control permit unless they emit greater than 5.7 pounds per hour of particulate matter, nitrogen oxides or volatile organic compounds (VOCs) or 3.1 pounds per hour of PM_{10}.

Small-scale generation is considered a minor source if it will emit less than the amounts in Figure 3-01. For more detailed information, see DNR publication PUBL-AM-055, May 1997, "Expanding Industry in Wisconsin, A Guide to Meeting Air Quality Requirements."

Figure 3-01 Prevention of Significant Deterioration (PSD) Pollutant And Significant Emission Rates

Pollutants	Emission rate (tons/year)
Carbon monoxide	100
Nitrogen oxides	40
Sulfur dioxide	40
Particulate matter	25
PM_{10}*	15
Ozone (VOC)	40
Lead	0.6
Mercury	0.1

*Particulate Matter of less than 10 micrometers

Normally, it takes 130 days to obtain an air permit. Once the application is received with a $1,000 application fee, the DNR will determine within 20 days if a permit is required. A preliminary determination for minor sources is made within 30 days. If no permit is required, the $1,000 is refunded.

Emissions

A major concern with fossil fuel fired DG technologies is that recent air quality improvements could be reversed if numerous small, uncontrolled sources of generation are installed. This is especially true for these sources when installed for emergency or peak-shaving conditions, since these conditions often arise on extremely hot, humid days when air quality problems already exist. Several generation technologies are compared for four major pollutants: NOx, SOx, CO_2, and particulates in Figure 3-02. These technologies are categorized by fuel type (coal, fuel oil, or natural gas) since fuel is a large factor in emission levels (see the following section).

The potential cumulative air pollution from numerous cheaper small generators powered by fuel oil and gasoline emitting below DNR's level of regulatory scrutiny, may lead to negative consequences to human health, particularly in non-attainment areas. This potential impact could be monitored by requiring all DG units connecting to the electrical grid to register with the interconnecting utility. The utilities could then make that information available to the PSC and the DNR as appropriate.

Fuel type influences air emissions

Power plants that burn coal emit SO_2, NOx, CO_2, particulates, and heavy metals into the atmosphere. Gas-fired power plants emit NOx and CO_2 and particulates. Emissions from power plants contribute to acid rain, which has been shown to damage lakes, streams, and forests. Power plant emissions also contribute to ozone formation, which can affect human health. Particulate matter, especially very small particles, can also adversely affect health. Emissions of CO_2 have been linked to global warming. Mercury and other heavy metals cause ecological and human health impacts.

When considering technologies that burn fossil fuels, natural gas is the fuel of choice because of its relatively clean combustion as shown in Table 3-02. Estimates are the use of natural gas will increase from 24 percent to 50 percent of all energy consumed by 2020. This shift in fuel use is expected regardless of any shift in the DG market. Natural gas use will further increase if tighter air emissions are established.

Coal quality changes would not be expected to impact the DG market, as technology and economies of scale would continue to require the construction of larger plants.

Efficiency and CO_2 Emissions

When the efficiency in burning fossil fuels is enhanced, substantial reductions in CO_2 occur. The efficiency values listed in Figure 3-02 clearly show the difference in efficiency. Enforcement of the Kyoto Protocol to reduce greenhouse gases world-wide would place greater emphasis on higher efficiencies.

Figure 3-02 Distributed Generation Emissions Comparison

Type of Unit	Plant Capacity	NOx (#/MWH)	SOx (#/MWH)	CO_2 (#/MWH)	Particulates (#/MWH)	Efficiency Percent	Footnote
Natural Gas							
Combustion Turbine (Neenah)	170 MW	0.61	0.02	1200.00	0.12	32	5, 11
Combined Cycle Plant (Badger Gen)	250 MW	0.07	0.01	800.00	0.12	58	10
New Internal Combustion Engine	1.5 MW	1.97	0.03	1100.00	0.10	40	2, 5, 8 (efficiency)
Microturbines (Allied Signal)	75 kW	1.10	0.02	1280.00	0.12	30	3, 4
Microturbines (Allied Signal w/co-gen)	75 kW	0.75	0.02	860.00	0.12	60	3, 4
Fuel Cell							
PEMFC	50kW-2MW	<.05		800.00	0.10	60	2 (efficiency), 9
PAFC	50kW-200kW	<.05		800.00	0.10	45	2 (efficiency), 9
MCFC	250kW-2.5 MW	<.05		800.00	0.10	65	2 (efficiency), 9
SOFC	50kW-2MW	<.05		800.00	0.10	46	5 (efficiency)
Fuel Oil (Diesel)							
Combustion Turbine (Neenah)	170 MW	1.93	0.57	1730	0.23	32	11
New Internal Combustion Engine (EPA TIER 2)	1.5 MW	16.00	0.01	1100.00	0.80	43	2, 5, 12, 13 (efficiency)
Coal							
Pulverized Coal Plant (Pleasant Prairie)	600MW	5.46	8.49	2434.14	0.11	32	1, 6, 14 (particulates)
Low Emissions Boiler System (LEBS) (Advanced Coal Plant)	400MW	0.80	0.80	1947.31	0.08	43	7

Values in gray represent distributed generation technologies

1. E-grid97.xls sheet EGRDPLNT LINES 42, 44, 45
2. Distributed Generation Technologies webpage
3. Manufacturers data, microturbines
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5. Power Engineering April 2000 p. 22, 26
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9. Enable Fuel Cells presentation – Univ. of WI, May 2000
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11. FEIS of Neenah, PSC
12. DG emissions data, DNR
13. Cat information bulletin, 3/20/2000, "Caterpillar Expands Cogeneration offering into Europe"
14. The values shown for NOx levels at Pleasant Prairie are without a selective catalytic reduction (SCR)

Efficiency of Various Generation Technologies

What is efficiency?

Efficiency is the percentage comparison of work output to work input. Work output is never greater than work input and thus, is never greater than 100 percent.

What is high efficiency?

Non-combustion renewable technologies are considered high efficiency by definition. It is suggested that combustion technologies with efficiencies of 50 percent or higher be considered high efficiency. This level will include the more efficient electrical systems that only convert energy into electricity. For renewable technologies that utilize combustion, such as biomass or sludge, 30 percent efficiency should be considered high efficiency.

For combustion technologies, the highest efficiency is achieved by the use of combined heat and/or cooling with electrical generation. Greater efficiency is attained by utilization of the waste heat. Older generating stations, located away from the end users, have electrical efficiencies of 20 percent to 42 percent with the only product being electricity. The remaining energy is discharged as heat into the air or water because transfer of useful heat to remote locations is not economical. New combined cycle generating units are approaching 60 percent electrical efficiency by utilizing what was the waste heat in a heat recovery steam generator (HRSG). For small-scale generation, efficiencies up to or above this 60 percent level are possible because of the utilization of waste heat.

Efficiency should be measured over a period of a year to discourage use and operation of technologies installed only for the purpose of receiving tax benefits.

Location influences efficiency

The location of generation will influence the total transmission and distribution line losses. Small-scale generation has the advantage of less transmission and distribution losses. The DOE estimates line losses of up to 10 percent occur with remote generation. For instance, a generating plant with 33 percent efficiency will actually be 30 percent efficient if measured at the customer meter. A breakdown of the losses is shown in Figure 3-03.

Figure 3-03 U.S.A. Electric System Loss Distribution Analysis

Generation	Losses as a Percentage of Total
Step-up transformer T1	0.32
230 kV and above transmission	0.53
Step-down transformer T2	0.37
69 kV transmission	2.94
Step-down transformer T3	0.66
Meter	0.36
25 and 12 kV distribution	2.94
Distribution transformer T4	1.77
Meter	0.90
Total	10.8

Source: Fourth Annual Distributed Generation and On Site Power, March 20-21, 2000, Four Points Sheraton, San Antonio, TX, DOE

Summary

Emission concerns due to the potential number and location of I/C engines and microturbines installed for DG purposes would suggest that all units connected to the grid should be registered with the utility, which in turn would report information to the appropriate state agency.

High efficiency for combustion and fuel cell units is easier to obtain with the utilization of waste heat. Since waste heat utilization is easiest and more economical to utilize at the source, DG has an inherent efficiency advantage.

High efficiency, in the context of small-scale generation is defined very differently for non-combustion technologies and those that burn fossil fuels. All renewable non-combustion technologies should be considered high efficiency. It is suggested that high efficiency should be defined as greater than 50 percent for CHP. For evaluation purposes and incentives, the measurement of high efficiency should cover an entire year of operation to account for seasonal changes such as heat rejection.

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Chapter 4 - Barriers

Introduction

Barriers to the greater use of small-scale distributed generation take many forms. Barriers can be technical, regulatory, or environmental. Sometimes barriers can also be created by business practices of an electric utility. Survey results, as shown in Appendix B of this report, identify a variety of barriers including those discussed in this chapter.

Interconnections Standards

Interconnection requirements imposed by an electric service provider can constitute significant barriers to the installation of small-scale DG facilities. Complex interconnection requirements that vary from service territory to service territory also constitute barriers to marketers and installers of DG.

This chapter discusses the technical, contractual, economic, and metering issues relating to the interconnection between DG facilities and the electric utility distribution system. Issues that must be addressed by interconnection standards include safety, power quality, system reliability, contracts, insurance requirements, tariffs, meter or standby charge, and metering.

Wisconsin rules

Wis. Admin. Code § 113.0207, "Requirements for utility rules for interconnection of small customer-owned generation facilities with the utility system," has been effective since October 1, 1982. These standards were developed to protect the safety of utility personnel and the integrity of the electrical system. Because both the nature of utility systems and DG technology have changed dramatically in the past 18 years, it may be time to review and update these rules particularly to reflect current national standards. One process to use in updating the rules would be to establish a collaborative effort with all stakeholders to make recommendations to the Commission for changes to PSC 113.0207. Early this year, the Wisconsin photovoltaic Working Group, Wisconsin SUN, and Energy Center of Wisconsin began such an effort for photovoltaic interconnection. This effort could be expanded to encompass all DG technologies.

National standards

The three national codes and safety organizations that would deal with DG facilities are listed in Figure 4-01.

Figure 4-01 National Codes and Safety Organizations

National Fire Protection Association (NFPA)	1 Batterymarch Park Quincy, MA 02269-9101 Phone: (617) 770-3000, Fax: (617) 770-0700 Web: www.nfpa.org
Underwriters Laboratories (UL)	333 Pfingsten Road Northbrook, IL 60062-2096 Phone: (847) 272-8800, Fax: (847) 272-8129 Web: www.ul.com
Institute of Electrical and Electronics Engineers (IEEE)	445 Hoes Lane, P.O. Box 459 Piscataway, NJ 08855-0459 Phone: (800) 678-4333 Web: www.ieee.org

The photovoltaics industry has led the way in establishment of utility interconnection standards for DG. In May 1999, the Underwriters Laboratory (UL) approved technical standards for grid connected photovoltaic systems. The Institute of Electrical and Electronics Engineers (IEEE) approved IEEE 929-2000 in January 2000, and is now working to expand this standard to include all DG systems. The proposed standard is designated as P1547. As of June 2000, 17 states (CA, DE, IL, ME, MD, MT, NV, NM, NY, OH, OR, PN, RI, TX, VT, VI, & WA) had adopted interconnection standards for photovoltaic systems. Without national and state standards, every utility could potentially have a slightly different interconnection standard for DG.

Other national codes that could apply to DG systems are listed in Figure 4-02.

Figure 4-02 National Codes

UL 1741	Requirement for Static Inverters and Charge Controllers
IEEE Std. 519-1992	Recommended Practices and Requirements for Harmonic Control
NFPA 70 Article 690 - National Electric Code (NEC)	Solar Photovoltaic Systems
NFPA 70 Article 705 (NEC)	Interconnected Electric Power Production Sources
UL 2200	Standard for Safety Stationary Engine Generator Assemblies

Safety - islanding

Islanding is an important safety issue for small-scale customer-sited systems. It is a condition where a portion of the utility system that contains both loads and generation is isolated from the remainder of the utility system but remains energized. When this happens with a DG system, it is referred to as DG-supported islanding. Problems created by islanding include interference with restoration of normal service, damage to connected equipment, and lack of voltage and frequency control in the island.

Power quality

Power quality is another technical concern for utilities and customer-generators. Power quality is analogous to water quality. Just as municipal water suppliers and individual water wells must meet certain standards for bacteria and pollutant levels, utility power needs to be consistently supplied at a certain voltage and frequency. In the US, residences receive alternating current (AC) power at 120/240 volts at 60 cycles per second (60 hertz (Hz)), and commercial buildings typically receive either 120/208 volt single-phase or 277/480 volt three-phase power depending on the size of the building and the types of loads in the building.

Power quality is important because electronic devices and appliances have been designed to receive power at or near these voltage and frequency parameters, and deviations may cause appliance malfunction or damage. Power quality problems can manifest themselves in lines on a television screen or static noise on a radio, which is sometimes noticed when operating a microwave oven or hand mixer. Noise, in electrical terms, is any electrical energy that interferes with other electrical appliances. As with any electrical device, a photovoltaic inverter, which converts the direct current (DC) power from the photovoltaic modules into usable AC power for a house, potentially can inject noise that can cause problems. In addition to simple voltage and frequency ranges, discussions of power quality include harmonics, power factor, DC injection, and voltage flicker.

Harmonics generically refers to distortions in the voltage and current waveforms. These distortions are caused by the overlapping of the standard waves at 60 Hz with waves at other frequencies. Specifically, a harmonic of a sinusoidal wave is an integral multiple of the frequency of the wave. Total harmonic distortion (THD) is the summation of all the distortions at the various harmonic frequencies.

Power factor is a measure of “apparent power” that is generated when the voltage and current waveforms are not synchronized. Power factor is the ratio of true electric power, as measured in watts, to the apparent power, as measured in kVA. The power factor can range from a low of zero when the current and voltage are completely out of synchronization, to the optimal value of one when the current and voltage are entirely synchronized. The terms “leading” and “lagging” refer to whether the current wave is ahead of or behind the voltage wave. Although not strictly the case, power factor problems can be thought of as contributing to utility system inefficiencies.

DC injection occurs when an inverter passes unwanted DC current into the AC or output side of the inverter. Voltage flicker refers to short-lived spikes or dips in the line voltage. A common manifestation of voltage flicker is when your lights dim momentarily. The significance of voltage flicker is highly subjective, but limits have been established by the IEEE. Grid-interactive inverters generally do not create DC injection or voltage flicker problems.

Regulatory

Regulatory barriers are of three types: contractual, utility regulation, and permitting.

The most obvious barrier is the case where the utility prohibits parallel generation by a DG facility or does not allow interconnection. The 1978 PURPA requires utilities to buy power from renewable generators, but this would not necessarily apply to fuel cells, micro turbines, and other small I/C generators. Another potential barrier is for the utility to raise the backup or standby tariff to a point where even non-parallel generation is not practical. Requiring a 30 kW win d generator to meet the same contractual requirements as a 100 MW cogeneration unit is not reasonable.

In some cases, utilities have imposed fees that eliminate any incentives for customer installation of a DG unit. These may include:

?? an interconnection study fee,

?? engineering review fees,

?? additional metering and "standby fees," and

?? separate T&D charges.

These fees and charges can very easily wipe out any economic advantage for small generators. A potential solution could be to consolidate these fees and make them commensurate with the size of the generating facility.

In Wisconsin, a large barrier for small-scale DG has been utility agreements that contain restrictive terms and conditions such as:

?? on liability insurance requirements;

?? indemnification requirements;

?? restrictions on transfer and sale of property.

Six states prohibit additional insurance requirements for net-metered facilities and others have limited the amount of liability insurance coverage that can be required In docket 6690-UR-112, WPSC asked for an increase from $100,000 to $300,000 in liability insurance coverage. The commission decision allowed the increase to a minimum of $300,000 for net energy billing customers.The uncertainty of the need to obtain an air permit can be a barrier for smaller fossil fuel powered generators and fuel cells. The $1,000 permit application fee can also be a problem for small-scale generators.

Service Infrastructure

DG resources require structural, mechanical, and electrical services for installation and operation. These services are largely available in the state. However, new types of DG will be introduced in the new emerging DG market. In addition, the IEEE is developing a universal interconnection standard for connecting DG with electric power systems. The IEEE Interconnection Standard–P1547 will be available in 2001. The new types of DG and the new interconnection standard for connecting them to the electric grid may necessitate a need for training and education for DG installers and building and fire safety officers. It may be appropriate to establish a fund to administer education and training programs for personnel engaged in DG installation and safety inspection. The Energy Center of Wisconsin (ECW) in consultation with the Department of Commerce and the Department of Regulation and Licensing may be used to identify the need for training and education. The ECW conducts research and training in high-efficiency energy technologies, and thus may be an appropriate organization for conducting training workshops for the DG installation.

Recommendations to Mitigate Barriers

Utility interconnection requirements can be major barriers to customer-owned, small-scale DG in Wisconsin. The following recommendations could be implemented with modification to PSC 113.0207:

?? Establish uniform, simplified standards based on IEEE-929-2000 for photovoltaic systems and IEEE P1547 for other DG systems. It is important that the technical standards be consistent from jurisdiction to jurisdiction within Wisconsin and from one state to the next.

?? Establish a statewide standard testing program for interconnection equipment based on appropriate NFPA, IEEE, and UL approved technical standards.

?? Establish a statewide-standardized contract for small-scale, high efficiency DG systems.

?? Combine interconnection fees into one fee that is appropriate for the size of the installation.

?? Consider discouraging utilities from requiring DG system owners to purchase additional liability insurance.

?? The cost of distribution upgrades associated with DG interconnection should be cost based.

Several stakeholders have suggested that to address these recommendation, the PSC could organize a collaborative effort among all stakeholders. These stakeholders include equipment installers and manufacturers, energy advocacy groups, environmental groups, electric and gas utilities, and staff from the PSC, DNR, DOA, and DOR.

Consideration should also be given to ways of mitigating the uncertainty associated with the need for an air permit.

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Chapter 5 - Economic Disincentives and Incentives

Economic disincentives and incentives exist in the emerging market for DG. This chapter will identify these aspects of the current DG market and suggest options a state program may employ to promote DG.

Existing Tariffs and Rules

One important program currently influencing the purchase and use of DG is the utility buy-back tariff. A buy-back tariff contains the terms and conditions by which a utility will pay its customer for excess electricity that the customer produces using its own generator.

On November 20, 1979, in docket 05-EI-1, the Commission ordered investor-owned utilities to submit such tariffs for review and approval or modification. The intent of these tariffs is to implement the requirements of PURPA, as discussed in Chapter 4, making affordable co-generation and parallel generation facilities including those that utilize alternative energy sources.

Wisconsin utilities continue to offer buy-back tariffs for the purchase of excess generation from both small- and large-scale customer-owned generators. Under the Wisconsin utilities' tariffs, buy-back rates differ by the size of the generator's rating. Although the buy-back tariff is one method that the state currently employs to promote DG, modification to the requirements for these tariffs may enhance this incentive for DG.

For generators over 20 kW, the buy-back rate is based on avoided cost or a negotiated rate. Both time-of-generation and blended buy-back rates are offered. No distinction is made between renewable and non-renewable fuels. A few utilities offer additional rate options for larger customer-owned generation.

Net metering is used for all customer-owned generation of 20 kW or less. This means that the amount of energy the customer takes from the grid is offset by the amount of generation it sends to the grid. If the customer is a net purchaser, it will be billed at the energy rate for its class of customer. If the customer is a net seller, it is paid one of two buy-back prices based on the fuel source. For non-renewable fuel sources, the price is based on a negotiated contract that is the same as generators over 20 kW. For renewable fuel, generally described as wind, solar photovoltaic, biomass, or wood waste, refuse derived fuel, or hydroelectric, the buy-back rate is the energy rate for its class of customer.

MGE offers a Volunteer Customer Generation Purchase Rider. This contract establishes a higher buy-back rate for generation dispatched at the request of MGE. The MGE tariff, however, is applicable only to customers with generation rated at least 75 kW.

Under the tariff rules, a parallel generation customer in Wisconsin is currently required to pay for the cost of all equipment and wiring for meter installation and for interconnection and parallel operation with the utility. In addition, the customer is required to pay for the cost of rebuilding any utility facilities required to adequately accommodate the parallel generation system

Demand-Side Application of Renewable Energy

Demand-Side Applications of Renewable Energy (DSARE) is a program of the Department of Administration's Energy Division. The program provides support to individuals, businesses, governments, and organizations for renewable energy projects in 23 designated counties in northeast Wisconsin. Demand-side renewable energy refers to solar energy, wind energy, hydropower, and energy derived from bio-mass or geothermal sources used primarily (over 50 percent) where it is produced. Financial assistance for qualified projects consists of:

?? low interest loans;

?? rewards for purchase and installation of equipment; and

?? performance-contracting incentives for contractors.

Participants

The market for DG contains the following participant groups:

?? electric utilities;

?? demand-metered industrial and commercial customers;

?? non-demand billed customers; and

?? independent power producers.

Each group poses a unique perspective on how to best utilize DG technology. Understanding these various perspectives can assist a policymaker's evaluation of the different methods that state government may employ to further promote growth in the DG market.

Electric utility

The best use of DG, from the perspective of an electric utility, is to support its distribution system. If planned correctly, DG can reduce a utility's cost of service by delaying or eliminating the need to build and upgrade its distribution system. DG can also reduce peak demand patterns, reduce transmission losses and improve the quality of service to outlying areas.

DG units sited in certain locations or used at certain times, however, are counter-productive from a utility perspective. Units sited at constraint points in the utility's distribution system may cause the system to overload. This situation would hasten the need for infrastructure upgrades and increase the utility's cost of service to the detriment of ratepayers as a whole. Units used to supply an individual's base load electric needs would substantially reduce utility revenues and jeopardize the company's financial integrity or require an increase in rates. The Commission sets the rate a utility can charge for electric service. The profits of a utility, therefore, vary inversely with its marginal cost of generation. During base load periods, the cost of generation is relatively low. Revenues from fixed rates charged at this period, therefore, provide the utility with the opportunity to collect sufficient profits. During peak demand periods, however, the cost of meeting that demand is relatively high because it may involve using fuel that is already in short supply, purchasing scarce excess capacity from another generator or dispatching an inefficient or otherwise expensive peak generating plant. Revenues from fixed rates may not cover the cost of generation during these periods. An individual utility customer if allowed, however, may choose to run its DG unit to satisfy its base load and rely on the utility to provide backup in emergency situations or to supplement its supply during peak periods.

An appropriate incentive program to promote DG from the utility perspective should encourage the utility or its customer to install DG units dispatched by the utility or used by the customer primarily to satisfy its own peak demand needs. Such a program should also encourage siting of these units in locations where their presence helps (not hinders) the distribution system.

Demand-metered industrial and commercial customers

The best use of DG, from the perspective of a demand-metered (DM) industrial or commercial utility customer, is to generate its own electricity when purchasing power from its utility is most expensive, as well as supplying power to the grid at peak demand periods. DM customers include large factories and office buildings. They are the biggest users of electricity on an annual average basis. A utility calculates its bill for a DM customer in two parts: a capacity charge and an energy charge. The basis of the capacity charge is the customer's highest amount of electricity use measured during the billing cycle. A DM customer can avoid increases in its capacity charge by maintaining a level demand throughout the billing cycle. The basis of the energy charge is the cost of generation measured at the time of use by volume. As the demand for electricity increases, as well as other items like fuel for generation, the cost of generation increases and raises a DM customer's energy charge. A DM customer can avoid increases in its energy charge by using less electricity at times when it is expensive to produce.

Some DM Customers achieve savings by allowing their utility to curtail electric service during its peak energy demand periods. This interruptible service enables a DM customer to avoid relying on its utility for its peak energy needs. By smoothing out its electric demand pattern, the customer reduces its capacity charge. To continue operating during a utility curtailment, these customers own on-site backup generation to produce electricity cheaper than taking it from the grid at peak amount or during constraint periods. The factors that influence a DM customer to take interruptible utility service or utilize backup generation include:

?? the amount of capacity or energy charges;

?? the customer's electric demand pattern;

?? the frequency the distribution system faces constraint periods;

?? the capital cost of backup generation;

?? the cost its utility charges related to the installation of the backup unit; and

?? the cost of on-site generation.

The rate a utility will pay for excess electricity its customer produces (buy-back rate), influences the capacity of the backup generator purchased by the customer. A customer that can make money selling electricity back to its utility during capacity constraint periods will buy a generator rated with more capacity than the customer's own requirements. By generating more electricity than it needs during these periods (parallel generation), the customer will sell instead of purchase electricity when energy charges are highest. Currently, the Commission requires utilities to pay large parallel generators either the avoided cost of the generation or a negotiated rate; but a DM customer can expect to receive less money for parallel generation than it would spend for continuing to take service from the utility.

An appropriate incentive program to promote DG from the DM customer perspective include the following:

?? a subsidy for the capital cost of DG units;

?? a limit to the cost that the utility charges related to the installation and interconnection of the DG unit; and

?? an obligation for or inducements to utilities to agree to buy-back rates profitable to the parallel generator.

Non-demand billed customers

The best use of DG, from the perspective of a non-demand billed (NDB) customer, is to generate its own electricity for base load requirements while continuing to rely on its utility for peak and backup electric service. NDB customers include small industrial and commercial, farm, and residential customers. A utility calculates its bill for a NDB customer by applying a single fixed volumetric rate to the customer's total electric use during the billing cycle. This rate covers both the capacity and energy costs for that use, including estimates for peak demand needs and use during constraint periods. The real cost to generate electricity during non-constraint periods is lower than this rate and the cost of generation during peak periods is greater than this rate. A NDB customer could save money, if it generated its own electricity during non-constraint periods and purchased power from the utility during peak periods.

A proper incentive program to promote DG from the NDB customer perspective would include the following:

?? a subsidy for the capital cost of DG units; and

?? a limit to the cost that the utility charges related to the installation and interconnection of the DG unit.

It might be possible for a NDB customer, like the DM customer, to supply power to support the grid. The purchase and operation of a generator rated with excess capacity must be more profitable than the money saved from simply purchasing electricity from the utility. Such profit might come from the enhancement of net metering, increasing the utility buy-back rate, or a production based tax credit.

Independent power producers

Independent power producers (IPPs) are owners and operators of large generating facilities that sell electricity into the wholesale market, usually during peak load periods. The best use of DG, from the perspective of an IPP, is to site multiple DG units in locations best suited to enhance reliability of the distribution grid. Currently, only the distribution utility knows exactly where load patterns place a constraint on its system and what amount of DG correctly sited would solve this problem. This knowledge is critical to an IPP because IPPs are currently only able to sell electricity to utilities at wholesale. For an IPP to make money, therefore, it must satisfy the needs of the utility. An IPP must, therefore, place any DG units it owns in places and with the capacity rating that corrects any constraints on the utility's system, otherwise, the utility will not dispatch the unit and the IPP will lose money.

An appropriate incentive program to promote DG from the IPP perspective would include the following:

?? attractive purchase power agreements; and

?? an obligation for or inducements to utilities to agree to cooperate with IPPs in system planning and siting of units to promote frequent dispatch.

New Incentive Options

Any incentive program to encourage the greater use of high-efficiency, small-scale DG in the state of Wisconsin would need to include the revision or promulgation of laws and regulations. The Commission recommends the establishment of a group of stakeholders, including equipment installers and manufacturers, customers, energy advocacy groups, environmental groups, gas and electric utilities, and staff from the PSC, DNR, DOA, and DOR to evaluate the recommendations discussed below and develop additional recommendations on a collaborative basis.

The May 2000 National Renewable Energy Laboratory report *Making Connections: Case Studies of Interconnection Barriers and their Impact on Distributed Power Projects* (NREL Report SR-200-28053) included ten suggestions for removing or mitigating barriers. Among them were the following three:

?? Develop tools for utilities to assess the value and impact of distributed power at any point on the grid. Utilities, regulators, and distributed generation proponents need to collaboratively develop these tools in time to support the new markets for distributed power.

?? Adopt regulatory tariffs and utility incentives to fit the new distributed power model.

?? Establish expedited dispute resolution processes for distributed generation project proposals.

The NREL Report suggests that economic incentives to promote DG should only be developed in circumstances where necessary. Such incentives could take the form of (1) low or no interest loans; (2) tax credits, accelerated depreciation, or depreciation for individuals; or (3) tariff incentives, including net metering and incentive pricing; and utility subsidized financing of a customer's own DG.

Some circumstances appear to already provide sufficient incentives. For example, a distribution utility concerned with customer rates and satisfaction should have the incentive to select the least cost option of either upgrading the distribution system or installing DG. Consequently, there may be no need to provide additional incentives to install utility-owned DG. Furthermore, where the placement of customer-owned DG will provide benefits in the form of support for electric distribution or transmission systems or power quality, DG could be constructed as an alternative to rebuilding the electric system. Because of the system benefit, it may be appropriate for some or all of these costs to be borne by the utility and recovered from the ratepayers.

Low or no interest loans

As discussed above, the DSARE program already provides low interest loans in several counties for the purchase of DG units that meet certain environmental requirements. An appropriate incentive for DG would be to expand these loans throughout the state. Before this expansion takes place, several questions must be answered, including:

?? Should the utility or the state provide the funds for such incentive?

?? Should any utility funding go to subsidize non-utility investment in grid supporting DG, especially if the non-utility is a competing IPP?

?? Should any utility funding subsidize environmentally friendly generation, if that generation does not support the grid?

Tax reductions

One drawback to the use of purchase and installation rewards that include tax credits and accelerated depreciation schedules is that they act to reduce the capital cost of the DG unit, but do nothing to promote the use of the unit and the consequent enhancement to the distribution grid or environmental quality. These are goals that appear as the focus of this report. An appropriate incentive program to promote DG should include a production-based tax credit that would offset a generator's taxes in any year that the generator operated its DG unit.

Tariff based options

As discussed above, most investor-owned utilities in Wisconsin already have buy-back tariffs. A proper incentive program to promote DG should include statewide buy-back tariffs. The existing tariffs could be amended to provide incentives, or a new tariff could be implemented. As will be discussed in greater detail below, the new tariff would need to define small-scale and high-efficiency, and would distinguish between distributed generation used for system support and distributed generation used for meeting environmental qualifications or encouraging the specified technologies. The buy-back rate would vary depending on whether the generation is dispatched by the utility or the unit's owner. The advantage of this is that it allows both the utility and owner to dispatch the unit.

There are a variety of methods that make buy-back tariffs generally more advantageous to DG owners. One method is real-time pricing. By adopting real-time pricing, the rate a DG owner would receive for contributing electricity to the grid would depend on the actual demand for electricity at the time of contribution. For interruptible customers, the price for electricity increases as the cost of generation goes up or when the customer needs an unusually large amount of power. Under real-time pricing, DG owners would increase generation for grid support during these periods because the buy-back rate would exceed its cost of operation. A variation of this could be zone-based real-time pricing.

Expanding the net metering tariff to include generation by customers with service of more than the current 20 kW maximum to a maximum based on the customers' peak load is another method that could make buy-back tariffs generally more advantageous to DG owners.

Support of electric distribution system

As discussed above, electric utilities should not be eligible for any incentive to develop utility-owned DG. If the economics warrant the generation, the utility will already have the incentive to develop it and the cost recovery would be incorporated into the rates.

In addition, not all customer generation should receive a development incentive. This is because not all generation is high-efficiency, small-scale, and strategically sited to be able to supplement central station generating plants and the distribution grid for the purpose of cost-effective power support. While strategically placed DG may be the least cost option for support of the distribution grid and generation systems, misplaced DG may cause or exaggerate grid constraints.

Similarly, not all output from strategically sited generation is required to supplement central station generating plants and the grid. A DG owner may choose to flow power onto the grid during periods in which the grid is not stressed. Also, since a grid is generally designed to meet infrequent and relatively large peak loads, a grid that requires DG support on a regular basis may need to be upgraded for reliability purposes.

For DG supplying grid support, the needs of the owner and the utility should be matched. First, the value of the generation is greatest at times when system reliability requires it to be dispatched. In addition, the utility relies on the generation being dispatched when needed. Consequently, a preferential rate for grid-supportive DG would be appropriate if the utility has the ability to dispatch the DG. Such a rate should be subject to Commission approval and filed in the utilities' tariffs. The rate should be greater than the customer energy rate or a rate negotiated between the utility and the customer. Second, the customer may have excess generation to send onto the grid during periods that the customer chooses to dispatch the unit. This generation should be treated as any other parallel generation and the buy-back rate should be the same as for all other parallel generation.

Because the availability of the generation could eliminate the need for upgrading the distribution grid, the unit's interconnection provides a ratepayer benefit. Consequently, the rules for the tariff should provide that the utility pay the cost of all equipment and wiring for meter installation and for interconnection and parallel operation with the utility and for the cost of rebuilding any utility facilities required to adequately accommodate the parallel generation system. The utility should be allowed to recover such costs from ratepayers.

Environmentally friendly and developing technologies

Existing buy-back rates include a premium for generation using renewable resources. All net sales to the utility, for units of 20 kW or less, are currently priced at the customer's energy rate. Under new incentive tariffs, generation that meets the definitions of high-efficiency and small-scale and that provides benefits in the form of environmental performance or employs the specified technologies, should qualify for buy-back rates equal to the greater of the customer's energy rate or a rate negotiated between the utility and the customer.

DG that is produced from environmentally friendly resources or developing technologies can also be strategically sited to support the electric distribution system. In such a case, the DG should receive the utility dispatched rate for energy generated at the utility's request and the developing technology rate for all other generation.

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Chapter 6 - Findings and Recommendations

Findings

The PSC makes the following findings concerning high-efficiency, small-scale electric generating facilities in the state of Wisconsin. These findings, which are discussed in the foregoing chapters of this report, are based on a survey of stakeholders, comments from other states, extensive literature research, seminars, and input from the DNR, DOR, and the Energy Bureau in DOA.

1. For these recommendations, high efficiency is defined as having system efficiency greater that 50 percent, where efficiency is determined by dividing energy in by energy out for a period of one year. Wind and solar are considered to be high efficiency by definition.

2. Small-scale is defined as a generator rated at one megawatt or less.

3. The lack of statewide uniform technical standards can constitute a barrier for interconnecting DG to the utility grid.

4. Uniform procedures for testing and certification of interconnection equipment are needed.

5. Complex interconnection contracts can add unnecessary cost and time to the installation of small-scale distributed generation. A detailed contract that may be appropriate for large customer-owned generators can create an unnecessary burden for a small-scale generator.

6. A barrier to market entry is created by interconnection rules and practices that vary from one utility service territory to the next.

7. Impediments to interconnection are created by outright prohibition of parallel generation, study fees, engineering review fees, additional metering fees, T&D charges, and standby fees.

8. Unreasonable insurance or indemnification requirements can unduly increase the cost of non-utility DG.

9. The current limitation that net energy billing is applicable only to units of less than 20 kW is too restrictive.

10. The existing rate structure includes a number of disincentives to non-utility small-scale generation.

11. The individual and cumulative effect of small-scale diesel generators could lead to air quality degradations in certain areas.

Recommendations

Any incentive program to encourage the greater use of high-efficiency, small-scale DG in the state of Wisconsin should include the updating of statutes, administrative rules, and utility tariffs. The Commission makes the following recommendations:

1. Establish a collaborative group made up of DG stakeholders, such as equipment installers and manufacturers, customers, energy advocacy groups, environmental groups, gas and electric utilities, and staff from the Wisconsin PSC, DNR, DOA, and DOR to develop additional recommendations as needed.

2. Establish uniform, simplified standards based on IEEE-929-2000 for photovoltaic systems and IEEE P1547 for other DG systems. It is important that the technical standards be consistent from jurisdiction to jurisdiction within Wisconsin and from one state to the next.

3. Establish state-wide precertification and standardized testing.

    ?? for interconnection equipment based on appropriate NFPA, IEEE, and UL approved technical standards; and

    ?? to measure efficiency at the point of manufacture.

4. Establish a statewide, standardized contract for high-efficiency, small-scale DG systems that includes:

    ?? a utility interconnection fee that is limited to one fee that is appropriate for the size of the installation.

    ?? a standard formula for determining the cost of distribution upgrades associated with DG interconnections.

5. Establish tariffs to cover:

- ?? expansion of the "Net Energy Billing" tariff availability for customers with service from the current 20 kW maximum to a maximum based on the manufacturer's equipment rating;

- ?? establishment of buy-back rates that vary depending on the environmental and grid benefits and dispatchability; and

- ?? rules that provide for the utility to cover all or a portion of interconnection costs in cases where there is a demonstrated benefit to the distribution grid.

6. Owners of DG units that provide a benefit to society at large, such as improved "environmental performance," could be granted a production-based tax credit. The level of tax credit could be pro-rated, based on the level of environmental impact.

7. Require all generation units that are connected to the grid to register with the utility that in turn reports size and location of these units to the Commission.

8. Provide state assistance to local units of government in siting DG technologies under existing planning and zoning authorities.

A

APPENDIX A - Distributed Generation Web Sites

http://www.aceee.org/ American Council for an Energy-Efficient Economy explores the frontiers of energy policy and energy efficiency.

http://www.awea.org/ American Wind Energy Association (AWEA) promotes wind energy as a clean source of electricity for consumers around the world.

http://www.avistalabs.com/relatedsites/default.asp Avista Labs . Fuel cell technology has been around awhile but the people at Avista Labs are making it a part of everyday lives.

http://www.cat.com/industry_solutions/shared/electric_power/electric_power.html Caterpillar Gen Sets deliver the power you need, when and where you need it.

http://www.ceeformt.org/ Consortium for Energy Efficiency (CEE) A national, non-profit public benefits corporation that promotes the manufacture and purchase of energy-efficient products and services.

http://www.clean-power.com Clean Power Research designs analytical methods to evaluate clean energy investments (photovoltaics, solar thermal, wind, energy efficiency) and builds software programs based on these methods.

http://www.powersavers.com Commonwealth Energy Corporation

http://www.dieselnet.com/standards.html DieselNet is the online information service on diesel exhaust emissions, emission control, diesel engines, fuels, and more...

http://www.dpc.org/ Distributed Power Coalition of America (DPCA) is an advocacy organization committed to advancing the use of distributed power.

http://www.ecw.org/ Energy Center of Wisconsin sponsors and conducts research in efficient use and management of energy, and develops, demonstrates, and transfers the results of that research to Wisconsin's energy service consumers and providers.

www.eren.doe.gov/greenpower/netmetering/index.shtml is the US Department of Energy's Efficiency and Renewable Energy Network (EREN) net metering site.

www.ieee.org Institute of Electrical and Electronics Engineers (IEEE)

www.irecusa.org/connect.htm Interstate Renewable Energy Council

www.ul.com Underwriters Laboratories (UL)

B

Appendix B - Survey Results

The Commission conducted a survey of 97 individuals and organizations whom it considered having interests in the DG. These individuals and organizations and the survey results are categorized in Figure B-01.

Figure B-01 Survey Participants by Category

Individuals or Organizations	Number of Surveys sent	Number of surveys returned
Academia	8	1
Consultants	2	1
Consumer Advocates	4	3
Distributed Generation Manufacturers	37	5
Entities Dealing with Natural Gas	3	2
Renewable & DG Advocates	10	2
Utilities	9	7
Utility Advocates	4	1
Others[2]	16	1

The Commission received 23 responses from the survey. The responses are briefly summarized below the questions.

Define "high efficiency."

- ?? For combustion technologies, most respondents suggested a CHP efficiency over 50 percent. However, for power generation only, the range was from 25 percent to 40 percent.
- ?? For non-combustion technologies, such as wind and solar, any energy conversion rate meets the considerations of high-efficiency.
- ?? A competitive market should define the high-efficiency.

Define "small-scale."

[2] Others included legal firms, state agencies, and International Brotherhood of Electrical Workers.

- ?? A size less than 100 kW and up to 20,000 kW was suggested to qualify as "small-scale."
- ?? Some respondents provided qualitative measures. One recommended that a renewable DG should generate not "more than 200 percent of the site owner's annual energy consumption over a five-year period," and that a fossil-fired DG should produce not "more than 100 percent of site owner's annual energy consumption over a five-year period." Another recommended, "[a] limit that best allows the development of standardized interconnection and permitting rules or guidelines." Yet another reported that a competitive market should define the size.

What technologies are available now, and will be available in the foreseeable future, for high-efficiency, small-scale electric generating facilities?

The following DG technologies were suggested*:*

- ?? Microturbine;
- ?? Fuel cell;
- ?? Wind turbine;
- ?? Solar/photovoltaic;
- ?? Internal combustion engine generator;
- ?? Sterling engine;
- ?? Biomass;
- ?? Combustion turbine;
- ?? Run-of-the-river hydro; and
- ?? Hybrid technologies

One respondent suggested: "Wisconsin allows the competitive market to determine what are and will be the most efficient generating technologies." Several others also opined that the market should determine efficiency, size, and type of DG technology.

The following storage technologies were also suggested to qualify as DG technologies:

- ?? Batteries
- ?? Flywheel
- ?? Pneumatic-hydraulic
- ?? Ultracapacitors
- ?? Superconducting magnetic energy storage (SMES)

What level of market penetration for high-efficiency, small-scale electric generating facilities (MW capacity and MWh energy) do you expect over the next 5, 10, and 15 years?

- ?? Opinions varied widely with a range of market penetration from 1 percent to 20 percent of the expected growth in electric demand in the U.S. over a period of 5 to 15 years.

What economic or regulatory barriers exist for the implementation of high-efficiency, small-scale electric generating facilities in Wisconsin?

If entry barriers exist, how should they be removed?

The following areas were identified to promote DG growth:

- ?? A universal interconnection standard;
- ?? Testing and certification procedures for interconnection equipment;
- ?? Allowing DG to participate in the grid and receive any economic benefits, such as costs of deferring transmission & distribution and peak demand shavings;
- ?? Streamline processing of DG application, permitting, and siting;
- ?? Non-discriminatory standby rates;
- ?? Encourage "customer choice;"
- ?? Make available methods and information for evaluation of DG decisions;
- ?? Target area and real-time pricing to signal strategic siting and sizing of DG; and
- ?? Unbundle distribution rates.
- ?? Other barriers identified were as follows:
- ?? Low cost of retail electricity in Wisconsin;
- ?? High initial costs of DG;
- ?? Dispatch control of DG;
- ?? DG ownership; and
- ?? Ability to finance DG.

What aspects of high-efficiency, small-scale electric generating facilities should be encouraged/discouraged by an incentive program?

For example: ranges of capacity and energy; useful life; levels/types of emissions; placement of units

- ?? Encourage strategic siting of DG through tariff structure to provide T&D support.
- ?? Encourage low-emission technologies.
- ?? Encourage technologies that use agricultural waste and landfill gas.
- ?? Encourage rural communities to install DG to serve their needs.
- ?? Encourage market driven technologies.
- ?? Encourage viable technology that will play a future role in power generation in Wisconsin.
- ?? Encourage dispatchable DG.
- ?? Encourage DG that provides both heat and power.
- ?? Encourage development of DG policies through participation of stakeholders.
- ?? Encourage real-time pricing.
- ?? Encourage DG of one MW or a few MW capacity.
- ?? Encourage DG useful life between 10 and 20 years.
- ?? Promote research and development in controlling a cluster of DG units.

What would an ideal interconnection standard look like?

- ?? Simple, safe, universal, and cost-effective.
- ?? The IEEE P1547 "Standard for Distributed Resources Interconnected with Electric Power Systems," currently being developed, will meet most of the requirements and reduce DG interconnection costs.
- ?? Promote development of interconnection standard for Wisconsin through a collaborative group.

What terms and conditions are appropriate for a high-efficiency, small-scale electric generating facilities tariff?

- ?? Current buy-back tariffs, including net metering, are appropriate for small-scale electric generation facilities.
- ?? Tariffs should allow all customers complete access to the market, regardless of the size or the type of DG.
- ?? Tariffs should address interconnection agreement, including availability, application process, rate structures, metering, liabilities, interconnection study costs, dispute resolutions, and contracts.

What technologies offer the best opportunity for power quality improvements?

?? It depends on customers' requirements, and may include power electronic devices, flywheel, ultracapacitors, and superconducting magnetic energy storage (SMES).

?? "All distributed generation technologies have the potential to improve local power quality through local voltage support."

?? A well-designed power electronic interface for DG units will help improve the power quality.

C

Appendix C - Acronyms and Abbreviations

AC	Alternating current
ACC	Arizona Corporation Commission
BTU	British thermal unit
CAA	Clean Air Act
CHP	Combined heat and power
CO	Carbon monoxide
CO_2	Carbon dioxide
CT	Combustion turbine
CTC	Competitive transition charges
DC	Direct current
DG	Distributed generation
DGI	Distributed generation and interconnections
DM	Demand-Metered
DNR	Wisconsin Department of Natural Resources
DOA	Wisconsin Department of Administration
DOE	United States Department of Energy
DOR	Wisconsin Department of Revenue
DP	Distributed Power
DSARE	Demand-side application of renewable energy
ECW	Energy Center of Wisconsin
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
GE	General Electric
GHG	Greenhouse gas
HHV	High heating values
HRSG	Heat recovery steam generator
Hz	Hertz
I/C	Internal combustion
IEEE	Institute of Electrical & Electronics Engineers
IPP	Independent power producers

kVA	Kilovolt amperes
KW	Kilowatt
kWh	Kilowatt hour
LEBS	Low Emission Boiler System
LHV	Low heating values
MCFC	Molten carbonate fuel cell
MGE	Madison Gas and Electric Company
MW	Megawatt
MWH	Megawatt hour
NAAQS	National ambient air quality standards
NASA	National Aeronautic and Space Administration
NDB	Non Demand-Billed
NEC	National electric code
NFPA	National Fire Protection Association
NG	Natural Gas
NOx	Nitrogen Oxides
NREL	National Renewable Energy Laboratory
PAFC	Phosphoric acid fuel cell
PEMFC	Proton exchange membrane fuel cell
PSC	Public Service Commission
PSD	Prevention of Significant Deterioration
PURPA	Public Utility Regulatory Policy Act
RPS	Renewable portfolio standards
SCR	Selective catalytic reduction
SMES	Superconducting magnetic energy storage
SO_2	Sulfur dioxide
SOFC	Solid oxide fuel cell
T&D	Transmission and distribution
THD	Total harmonic distortion
TSP	Total suspended particulate
UL	Underwriters Laboratories
VOC	Volatile organic compounds
W/m^2	Watts per meter squared
WEPCO	Wisconsin Electric Power Company
W_I	Work input
W_O	Work output
WP&L	Wisconsin Power and Light Company
WPSC	Wisconsin Public Service Corporation
WRAP	Wind Resource Assessment Program